design ideas

Edited by Bill Travis and Anne Watson Swager

Voltage reference sets current limit

Joe Engle, Burr-Brown Corp, Tucson, AZ

Power op amps have a real need for active output-current limiting. Most power-amplifier designs rely on the voltage drop across a user-supplied sense resistor to turn on an internal transistor. This method has several drawbacks, notably, an inability to change the current-limit point under program control. The current-limit circuit in **Figure 1** allows you to establish the setpoint by applying a voltage to one of the amplifier's pins. With this design, it is possible to set the current-limit point with the output of a DAC, possibly under the control of an embedded µC.

The OPA547 is a true op amp; thus, it does not need a connection to power ground. The current-limit-setting voltage for this IC uses the negative supply as a reference. For single-supply applications in which the negative supply is ground, this referencing technique presents no problem, but for circuits that use a negative supply below ground potential, you need a different technique. The circuit in **Figure 1** shifts the reference potential for the control signal from ground to the negative supply. For simplicity, **Figure 1** shows the OPA547 as an inverting amplifier, but you can use any op-amp application circuit. The circuit uses an OPA340 for reference shifting because it is capable of rail-to-rail operation on both input and output.

To understand the operation of the reference-shifting circuit, first recognize that the R_3-to-R_4 voltage divider sets the voltage at IC_2's Pin 3. Thus, the intermediate voltage (V_i), as measured from the negative supply, is given by

$$V_i = V_C \frac{R_4}{R_3 + R_4}. \qquad (1)$$

To find the voltage at IC_2's pin 2, note that the current through R_3 equals the sum of the currents in R_1 and R_5, leading to the following expression:

$$\frac{V_I - V_i}{R_2} = \frac{V_i - V_O}{R_1} + \frac{V_i}{R_5}. \qquad (2)$$

As long as op amp IC_2 operates in the linear region, the voltage at Pin 2 equals the voltage at Pin 3, so the value of V_i in each of the expressions is equal. When you substitute the first term into the sec-

I (mA)	V_C
0	4.75
100	4.12
375	2.38
500	1.59
750	0.01

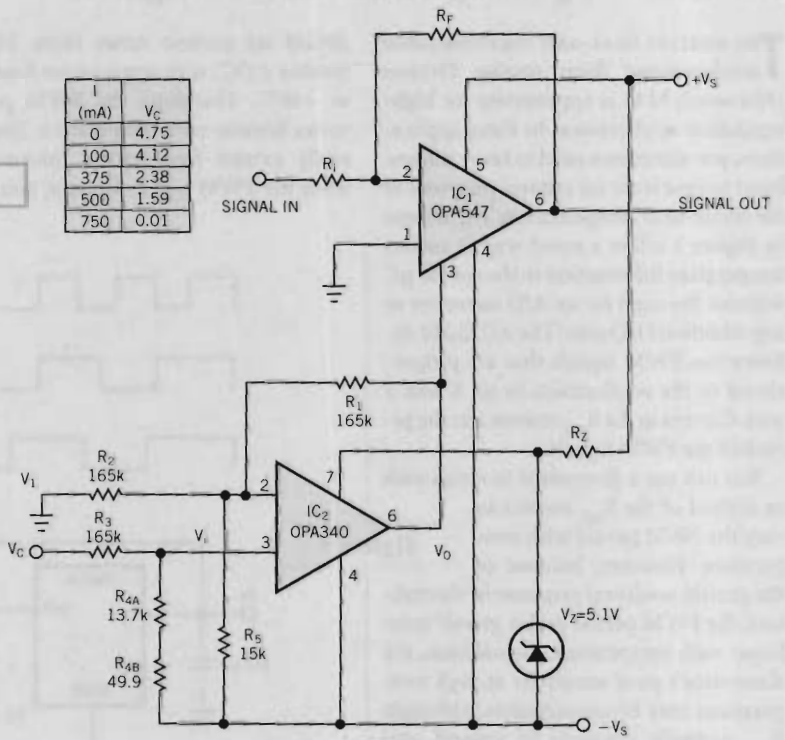


Figure 1 You can use a difference amplifier with wide common-mode range to control a power amplifier's current limit.

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ond, set R_1 equal to R_2, and combine terms, the resulting expression is

$$V_O = V_C\left[2+\frac{R_1}{R_5}\right]\left[\frac{R_4}{R_3+R_4}\right]-V_1. \quad (3)$$

In **Figure 1**, V_1 connects to ground, and you obtain unity gain by setting the coefficient of V_C in **Equation 3** to 1. If you expand and combine terms, the expression becomes

$$1+\frac{R_1}{R_5}=\frac{R_3}{R_4}. \quad (4)$$

To change the scalar relationship between the controlling voltage applied to the power op amp, simply set the coefficient term to the desired value and solve **Equation 3**. To determine the resistor values, consider the worst-case common-mode voltage that IC_2 can encounter. OPA547 allows a maximum supply differential of 60V. In an extreme case, the positive supply of the OPA547 connects to ground and the current-limit set voltage is +5V. **Equation 1** becomes

$$5=65\frac{R_4}{R_3+R_4}, \quad (5)$$

which reduces to $R_3=12R_4$. Applying this ratio to **Equation 4** and setting R_3 equal to R_1 produces $R_1=11R_5$. Selecting from a list of standard 1% resistor values yields the values in **Figure 1**. Note that the stage operates with a common-mode voltage that equals the negative supply. Errors in the resistor values can produce a significant offset shift. With this circuit, it is possible to set the current limit of the power op amp to a known, repeatable value under program control. (DI #2270).

To Vote For This Design,
Circle No. 406

Accelerometer output gives temperature info

Harvey Weinberg, Analog Devices Inc, Cambridge, MA

The ADXL202 dual-axis micromachined accelerometer from Analog Devices (Norwood, MA) is appropriate for high-resolution applications. In these applications, you sometimes need to know the ambient temperature for control purposes or for circuit-drift compensation. The scheme in **Figure 1** offers a novel way to convey temperature information to the system µC without the need for an A/D converter or any additional I/O pins. The ADXL202 delivers two PWM signals that are proportional to the acceleration in its X and Y axes. Current in the R_{SET} resistor sets the period of the PWM signals.

You can use a thermistor in series with or instead of the R_{SET} resistor to vary the PWM period with temperature. However, because of the grossly nonlinear response of thermistors, the PWM period is also grossly nonlinear with temperature. In addition, the thermistor's poor sensitivity at high temperatures may be unacceptable. Although R_{SET} normally connects to ground, you can connect it to any noise-free voltage source ranging from 0 to approximately 1.2V (at which voltage the internal current source runs out of compliance). By connecting R_{SET} to the V_{OUT} pin of a TMP36 temperature sensor, the PWM-period set current varies fairly linearly (within ±5°C) with temperature from –20 to +40°C. Therefore, the PWM period varies linearly with temperature. You can easily extract temperature information from the PWM signal, because you normally measure the period to determine duty cycle. (DI #2271).

To Vote For This Design,
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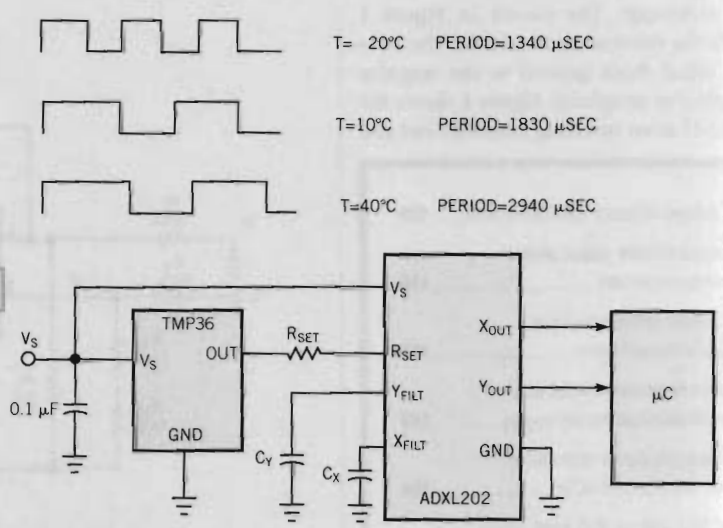


Figure 1

An accelerometer can do double duty, by supplying both acceleration and temperature information.

Voltage comparator forms pulse demodulator

Abel Raynus, Armatron International, Melrose, MA

To process low-level ultrasound or radio-range pulses, you need a signal-conditioning amplifier followed by a pulse demodulator to translate the signals to dc pulses. Traditionally, you would use a diode-demodulator configuration (for example, the circuit in **Figure 1a**) with one stage of a single-supply op amp. The circuit in **Figure 1b** does the same job but uses a voltage comparator instead of a diode demodulator. The key to the method is choosing a threshold voltage (V_{TH}) on the negative comparator input that is slightly higher than the dc level of the amplifier output, which is equal to or close to $V_{CC}/2$. The R_4-to-R_6 resistive divider determines the difference between the op-amp bias and the threshold voltage. This difference, calculated to yield an acceptable signal-to-noise voltage, is $V_{CC}R_5/(R_4+R_5+R_6)$.

Or, assuming $R_4=R_5+R_6$, the difference is $V_{CC}R_5/2R_4$. R_3 and C_2 make up a lowpass filter. This pulse demodulator has some advantages: First, its sensitivity is higher than that of a diode demodulator. A 25-mV, 40-kHz, 1-msec input pulse produces a 0.1V output pulse in **Figure 1a**'s circuit, and a 2V output pulse in **Figure 1b**'s circuit. Second, it's convenient and economical to use one more stage of the dual or quad op amp instead of adding discrete components. (DI #2273).

To Vote For This Design, Circle No. 408

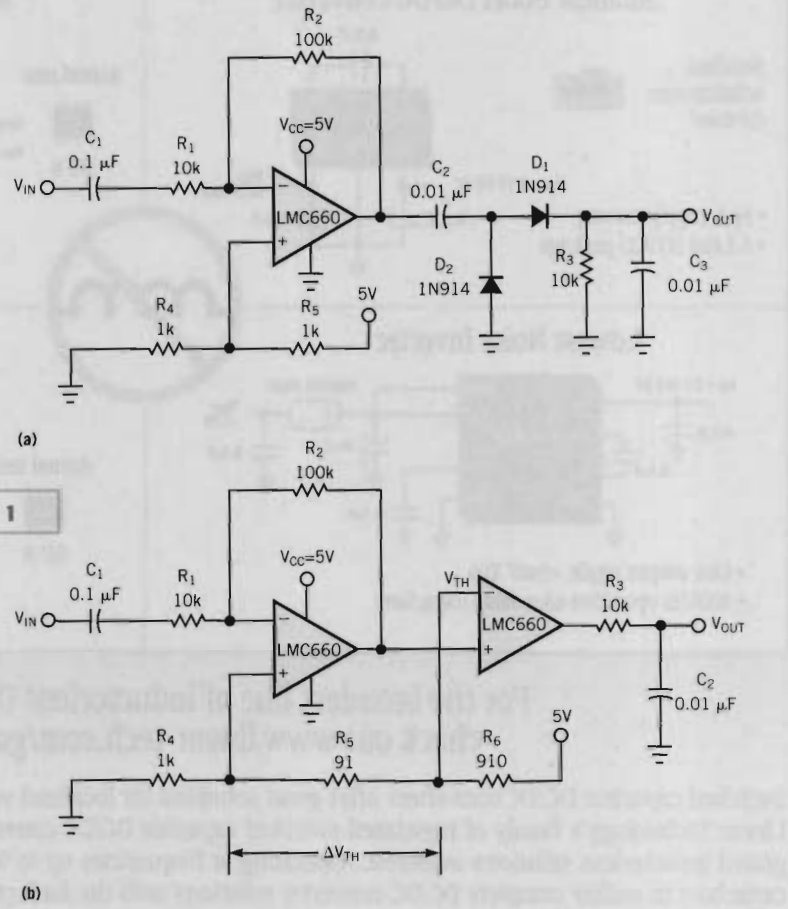


Figure 1

The passive, diode-based approach to pulse demodulation (a) provides a lower sensitivity than the active approach (b).

Watchdog-reset catcher aids embedded-system debugging

Scott Newell, PCSI, Fort Smith, AR

A simple "junk-box" circuit uses a 4013 CMOS flip-flop and a handful of passive components to determine whether random resets are the result of a blown stack or the result of the watchdog-reset circuit tripping (**Figure 1**). You can also use this circuit to "grab" and hold other logic level edges like memory or I/O accesses.

A logic-level rising edge at the clock input (Pin 3) of the 4013 clocks the flip-flop. Because the circuit holds the data input (Pin 5) high, the Q output (Pin 1) goes

high, which turns on the LED. Once the LED is on, the circuit ignores any further changes at the input.

R_1 and C_1 are the power-up reset for the flip-flop. At power-up, C_1 discharges, which holds the reset input (Pin 4) of the 4013 high, clears the Q output of the 4013, and turns off the LED. C_1 charges up to the supply voltage through R_1, taking the R input (Pin 4) low to deassert the 4013 reset time. D_1 discharges C_1 quickly on power-down. S_1 is an optional reset switch. C_2 is a power-supply bypass capacitor. Don't forget to ground all unused inputs on the 4013. To reset the circuit, either momentarily close S_1 or temporarily disconnect power.

You can solder all the parts onto a BNC, which makes it easy to connect a scope probe directly to the watchdog-reset catcher. You can use a clip lead for the power line and easily steal power from the device under test. You can then connect the output of the embedded system's watchdog-reset circuit through the scope probe to the clock input of the 4013.

None of the part values are critical, and many types of flip-flops can substitute for the 4013. A faster flip-flop may be necessary to watch fast signals. Adding an inverter to the input would allow you to catch falling edges, such as active-low reset signals. (DI #2293)

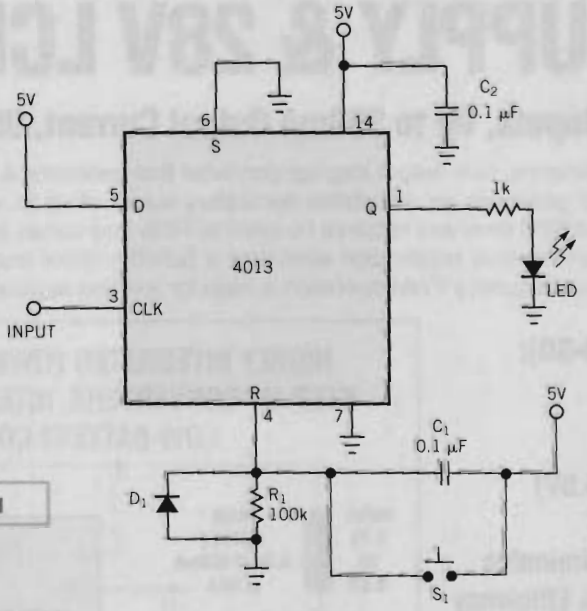


Figure 1

NOTES:
LED=HIGH-EFFICIENCY RED LED.
D_1=IN4001 OR ANY OTHER SMALL-SIGNAL DIODE.
S_1=OPTIONAL MOMENTARY PUSHBUTTON SWITCH.
TIE UNUSED INPUTS TO GROUND.

A 4013 CMOS flip-flop and a handful of passive components monitor the activity of an embedded system's watchdog reset.

To Vote For This Design, Circle No. 409

Easily display bit-map images on small-graphic LCDs

Todd Fitzsimmons, Densitron Corp, Santa Fe Springs, CA

Combining a high-level language, such as Microsoft Windows, with low-level assembly code or C++ code allows you to display perfect bit-map pictures on your small-graphic LCD screen. You can use Microsoft Paint or any other bit-map-generating program to define and edit the picture. Unlike segmented and alphanumeric LCDs, small-graphic LCDs are fully graphical and can display logos, graphs, or any other image in addition to numbers and characters. The main hurdle to upgrading to this type of display is the software necessary to display the bit-map pictures.

To create your bit maps, you can use any available bit-map program, such as Microsoft Paint. After opening this program, select the Attribute menu. At the prompt, you enter the LCD size you are using and then choose the monochrome-bit-map option. You can now close the Attribute window and start drawing, typing, or pasting the images you want. After saving the pictures, you need to attach the bit maps to the end of your assembled or compiled program in order of their intended use. You can attach them using the COPY/B command in DOS, which differs from the regular COPY command by copying directly as a binary format without adding a byte of data at the end.

To use these attached bit maps, you need a subroutine in your program, such as the 8051 assembly code in **Listing 1**, which can pull the data out of the lower memory and send it to the display. (You can download this listing from *EDN*'s Web site, www.ednmag.com. At the registered-user area, go into the Software Center to download the file from DI-SIG, #2295.) This code clocks in bit maps to the SED1330 controller chip on a 240×320-pixel display. If your display doesn't use the SED1330 chip, you can still use this code with modifications to the WRCMD and WRDATA subroutines and possibly some alterations on the direction you clock in the data. The di-